WHY COMPUTER PROGRAMMING IS NOT QUITE MATHEMATICS: IMPLIED TELE-COMMUNICATIONS POLICY

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ABSTRACT

The paper/presentation co-ordinates two computer science matters:

(A) Mathematician Kemeny's speculation that algorithms, not mathematics, are better for capturing the dynamics of organizational/management systems [Also true of any system containing at least one biological (living) element.]. (See Kemeny—and Dewan's preface—in *CYBERNETICS & THE MANAGEMENT OF LARGE-SCALE SYSTEMS*.)

Any algorithmic model of an actual system is typically in a machine-readable format, so that the procedure for 'reviewing' such models is characteristically different from 'verifying and validating' a mathematical treatise. The recent "proof" of the 'Four-colour Problem' requires impeccable correctness in the computer programme which purportedly examined the many, many configurations for their constrained 'colourisation'.

(B) We review our previous TCF presentations to uncover those aspects of our national tele-communications policy which are required by—and which also make possible—the scientific scrutiny of any computer-directed (programmed) model.

AN EXTENSION TO THE ABSTRACT:

In Portion I (of the two Portions of this paper), we review and examine both Kemeny's Conjecture and Bellman's Prognostication, concluding therein with remarks on the educational distinction of computer programming from mathematics.

We will move in the second Portion (II) of the paper to show additionally how one can resolve economically—and yet with a concurrent legal basis—the difficulty facing newspapers worldwide as they have been attempting to compete with online "bloggers" via Internet messaging, which to date have been deemed to be "free" transmissions.

Portion I.Ø: An Extended Introduction.

We recall two early contributors, mathematicians, to the literature of the then-developing field of computer science, itself now accepted, like statistics, as a member of our *mathematical sciences*:

A) John Kemeny, President of Dartmouth College, had conjectured in 1968 [*CYBERNETICS AND THE MANAGEMENT OF LARGE SYSTEMS*, New York, pp. 65, 67] that, in order to capture the dynamics of large-scale, social systems, one would be better served by using computer programming, not mathematics. (His speculation was expanded in that volume's Editor's [Dewan's] subsequent interview of Dr. Kemeny, the latter noting that the enabling distinction is probably due to the algorithmic nature of computer-programming.)

B) Even earlier, mathematician Richard Bellman had in 1953 [*STABILITY THEORY OF DIFFERENTIAL EQUATIONS*, New York} called for a resolution of the fundamental problem in the theory of differential equations (viz., "deducing the properties of solutions of a given differential equation from the analytical form of the equation"). Then, in 1968, Bellman's monograph [*SOME VISTAS OF MODERN MATHEMATICS*, Univ Ky Press], though not reporting on his earlier announced call, noted the likely predominance of computerized modeling to the resolution of biological, primarily medical, questions.

In Vol. 92 of Bellman's series of monographs, prepared in 1970, published in 1972, a connexion between the two conjectures/prognostications was developed, referring to the then evolving simulation programming languages as "ad hoc" languages, meaning that they were designed explicitly of the purpose of simulating the dynamics of systems more general than those which had been capable of modeling via mathematics . The distinction that Kemeny had merely suggested was here made quite explicit [See *SIMULATION; STATISTICAL FOUNDATIONS AND METHODOLOGY* (Ref 7), 1972(1970)].

Since mathematics and computer-programming are linguistically different (as used by scientists: third-person grammar vs. second-person), we develop the value of making this distinction within university-level mathematics education. It appears that leading near-anthological works in the biological sciences [e.g., James Miller's *LIVING SYSTEMS*, McGraw-Hill] showed that the dynamics of any biological system—as lowly as the cell or as complicated as the human society—is conducted by a central sub-system: its 'decider' element. Yet, it the algorithm which captures explicitly a decision-making procedure: The algorithm is a recipe for making that decision.

Our presentation here—in this Portion I of the paper—will develop several examples to illustrate the educational facets illustrating the distinction between the linguistically different aspects of our mathematical sciences: mathematics and computer-programming. In so doing, we will also compare mathematical versus computational biology, providing conditions for establishing a favourable view of each.

We ask and answer the query, "Why does it matter to biologists that computer programming is not mathematics?".

Each is a language which can be chosen by a scientist/biologist for the purpose of constructing his/her model of the biological system which has been observed. Yet, the two languages are linguistically quite different: 1) Mathematics, when used by a scientist, is a third-person language, as a voiced reading of the sentence, 'F = mX a', should reveal; 2) Yet, computer programming, being algorithmic, is grammatically second-person, as a reading of the "assign" statement, 'Y = Y + DY', should uncover.

Yet, any biological system, unlike a strictly physical one, possesses one or more decision-making activities, whether that system be as elementary as the cell or organ, or is as complicated as an organism or even a herd or a human society/organization. Any algorithm is a programme describing a decision (or, a decision-making activity), so that, once programmed and activated on a computer, it is a set of instructions by which the computer can precisely mime , if and when 'called', that particular biological decision. Thus, when programmed and computerised, such an algorithm can make the change within the (model of the) biological system, thereby providing a precise mimicry of the dynamics of the modelled system, itself better referred to as the *simuland* [cf. *OXFORD ENGLISH DICTIONARY*].

We show examples of how strictly mathematical models can contribute to the scientific understanding of biological systems, but provide exemplars of the likely preference, among biologists, for algorithmic simulations. Algorithmic model-building can thus be viewed as an innovative mathematico-logical method for biological models.

In addition to this comparative study, we provide an extended bibliography, one relating our human-conducted model-building process itself directly to biological evolution and therefore to interdisciplinary education (e.g., biology, sociology, sociobiology).

Portion I.A: Mathematicians' Comments As Computers Were Arriving.

Richard Bellman's call [1] in 1953 for a resolution of the fundamental problem in the theory of differential equations [viz., "deducing the properties of solutions of a given differential equation from the analytic form of the equation"] has kept many, many of us mathematicians occupied during the second half of the 20th Century, even until today.

Mathematician John Kemeny [3] had speculated in 1968 at a conference on cybernetics and large systems that *something* about computers was different than mathematics and that this difference held great promise in our attempts to model the dynamics of social systems. Bellman [2] that same year repeated his hope that mathematicians, through/via time-dependent differential-difference equations, should contribute greatly to a medical understanding of biological systems (organs in particular).

Yet, Kemeny [3, p. 65] had stated:

"in trying to dabble a bit in the application of <u>mathematical</u> models to the social sciences…I came to the conclusion that the shortcomings…far outweigh the advantages." Later in his paper, Kemeny added: "You start with a problem that's clearly discrete. It has a finite number of parts, with a finite number of connections; You're dealing with a finite amount of time, very often in discrete stages. However, you are used to working with continuous models and therefore…you come up with a very lovely partial differential equation…[and use your] great tool to approximate the continuous equation by a nice discrete model and then go solve it on a computer." .

[N.B.: Editor Dewan's report [3] of his post-Conference interview with John Kemeny, recorded in the book's Preface: Kemeny conjectures that the advantages of computer programming languages over mathematical structures, may lie in their being algorithmic.]

In 1972, Volume 92 of Bellman's series of monographs was published [7] by Academic Press. The book, on simulation methodology, referred to the then evolving simulation programming languages as "ad hoc" languages, meaning that they were designed explicitly for the purpose of simulating the dynamics of any more general system, though at the time it might still have been perceived by mathematicians, like Kemeny, that these languages would just accommodate discrete, rather than continuous, yet <u>mathematical ,</u> formulations. The distinction that Kemeny had merely suggested was here made quite explicit in 1972(1970).

We shall underscore in the present paper that mathematicians and computer programming are <u>linguistically</u> different and, furthermore, that this very difference is just what is required for us in the "mathematical sciences" to capture with scientific credibility the dynamics of any biological, or living, system.

Portion I.B: Computer Programming.

Most are aware that a programme, whether written in basic code or in one of the higher-level computer programming languages (e.g., FORTRAN, GASP, SIMSCRIPT), demands a logical precision at the equal of that found in strictly mathematical work.

However, we mathematicians are accustomed to using *our* language to demonstrate the *proof* leading to some earlier announced conclusion. Indeed, even applied mathematicians take pride in demonstrating the logical impeccability of their conclusions, even when each variable has been used to describe some real-world attribute (rather than just some quite abstract concept, like a line or a circle, and/or some concept which, to the pure mathematician, requires no actual specification of a real-world entity).

Computer programming, on the other hand, is seldom used to <u>prove</u> that a logical conclusion has necessarily been reached. Even the case of the proof of the 'four-colour problem', while using a computer, was merely the use of a computer programme to 'simulate' a mathematician carrying out, one-by-one, a barely finite number of comparisons until the complete list of possible theorem-denying configurations had been exhausted.

We should appreciate that, to a scientist, mathematics is merely one language which he <u>may</u> select to present the model of (his explanation for) the naturally occurring phenomenon which he has been observing. Newton's laws of motion, e.g., were expressed in our language of mathematics, whereas Darwin's [Law of] Evolution was expressed in natural language.

To wit (One perhaps should read <u>aloud</u>):

Newton's expression,

" $F = mXa$, (1)

wherein F is force, m is the mass, and a is the second derivative of position with respect to the passage of time,"

noting that the reading is grammatically a third-person expression. Darwin's *Origin of the Species*, however, is grammatically a first-person account, in effect saying ' I took a trip around the world, I made the following observations, and I have reached the conclusion that living organisms, particularly their species, have evolved from (i.e., have found, though not cognisantly, that slight alterations in their genetic makeup are an advantage for them, with the passage of time, over) earlier species.'

We should be aware that computer programming is distinctly different from either mathematics (third-person) or natural language (first-person). Indeed, it is interesting to note that *Science* Magazine has long been requesting that manuscripts submitted to its editor are preferably to be written in first-person grammar.

However, scientists now possess an alternative linguistic format for presenting their scientific conclusions: viz., computer programming. Yet, most of us seem not to appreciate that computer programming, despite its requirement for logical and grammatical rectitude, is distinctly different from mathematics.

For example, the expression (in FORTRAN, e.g.),

'Y = Y + DY', *(2A)*

could be equivalently expressed, when read as mathematics, as

'For any value of Y, DY = 0' , (2B)

not at all what Expression (2A) means in FORTRAN.

Rather, to the computer to which Expression (2A) is directed, one reads instead

'You (Computer) assign a memory location with the name Y, another with the name DY; then, if ever this very expression is encountered as you (the computer) circulate through the computerised and activated programme, then you add the present value of the location Y to that from the location DY, and then replace (assign) the value in the location Y with this resulting sum.',

a quite second-person grammatical sequence: actually, it is an *algorithm* for accomplishing the desired task.

Similarly, the statement

$$\text{‘ } \mathit{IF\ IX\ THEN}\ \alpha,\ \beta,\ \chi \text{ ’,} \quad (3)$$

is one which a pure mathematician would not recognise as one within his language at all;

however, to a computer programmer, it is a "Conditional Go To" statement, an algorithm for the computer to follow so as to decide which of three instructions (α, β, χ) next to access and then to follow, dependent on the then current value of *IX*.

An *algorithm* therefore describes a decision-making process [7], or as Wheatley and Unwin [11] note:

" *An algorithm is a mathematical recipe, and from this its meaning has been extended to cover a recipe in any field of activity.* "

Indeed, when the present senior author, while preparing the manuscript [7], kept mentioning "algorithms" to today's junior author, she asked just what is an "algorithm": My response to her, in explaining the term, led to her quick reply: "That's just a recipe!"

Of course, one cannot conclude that we mathematicians do not within our literature include algorithms. Some proofs are so conducted: e.g., Euclid's algorithm; or, also, any of the construction proofs in geometry, are examples of algorithms used by mathematicians. Yet, the language of mathematics, when used by a scientist such as Newton, is not at all algorithmic.

Portion I.C: Science and Computers, with or without Mathematics

However, in the present paper, we note that a scientist, seeking to describe the dynamics of a system which he has been observing, has *two alternative linguistic formats* (other than using his natural language

{See Laplace's book [5] on probability, very tedious reading [in either French or English] because he (intentionally!) used no mathematical symbolism or shorthand.}:

Mathematics, via differential or difference equations;
Algorithmic *computer programming* languages.

We shall return to the value of each of these two formats in the next section, but first wish to correct a commonly held misunderstanding of Science by many, if not most, mathematicians.

Science is that human activity devoted to providing the very explanation for (i.e., providing the truth about: cf. *Oxford English Dictionary*) some particular naturally occurring phenomenon. A scientist conducts his work in accordance with the Scientific Method [8], itself a six-stage model-building process [6] by which Human Knowledge is acquired and accumulated. Two Nobel Laureates have commended these depictions [8: Preface].

We include here Table I, an annotated bibliography, which reveals not only that the six-stage model-building process—which computer science recognises and employs—itself provides a compact (and nearly algorithmic) model of the Scientific Method itself, as conducted historically, but also that the latter process by which our species builds models (for storage in libraries and museums, including cave walls!) actually mimes stage-by-stage the biological process by which survival is (and has been) ensured.

Actually, this quite biological model-building process was first 'employed' (though not cognisantly) by species using chemico-genetic models, but then the same six-stage model-building process was 'employed' by the "higher" animal species (= those with neural systems capable of memory-and-recall) in a process which enhances, using chemico-neural models, the biological survival of an individual member of the species to his/her own age of puberty. One single biological model-building process can account for the survival of all Life on Earth to date: chemico-genetic for plant and animal species; chemico-neural for the 'higher' animals.

Hence, our computer science has contributed, in this manner, to a greater understanding of biological evolution. Furthermore, we are unique among the species in that we are the only species which constructs for survival models outside the brain and outside the genetic system [12]. Computer-directed, algorithmic models, if authored and then deemed credible by means of our model-building process, are latter-day exemplars of the biological model-building process which have ensured the survival of all Life on Earth to date. See Figure 1.

Important for the current discussion is that Science progresses (that is, a scientist proceeds) by, very importantly, *first* observing a naturally occurring phenomenon, writing down data if this will enhance or make more precise his recall of any observation. Then, upon reflection, he reaches the "Aha!" state (= end of Stage I), recognising that he has understood the phenomenon. The succeeding stages [II: Artwork; III. Perscrutation of the Artwork; and then IV. Confirmation (of the scrutinised artwork by Nature itself)] deal, respectively, with writing/constructing the model, having it reviewed and/or corrected, and then confirmed by others to ensure that any impeccably logical deduction derived by having accepted as true the published 'model' holds forth in Nature.

As a "Confirrmation Test" for the validity of the model (Figure 1) itself, the interested reader would do well to examine the description of the discovery of the planet Neptune [4], an historical account of the resolution of the challenge which Newton's mathematical model for planetary motions was suffering once it was discovered that Uranus was no longer in the position which Newton's equations would have predicted. The astronomical location of Neptune in the mid-19th Century served therefore as another extremely important 'Confirmation' of Newton's Laws of Gravitation.

Unfortunately, too many of us mathematicians have viewed our theorem-proving activity to be an exemplar of the Scientific Method itself. Of course, a mathematical theorem need not refer to any exterior matter in the real world: this fact alone would not allow most of [pure] mathematics to qualify as scientific. But, more importantly, we too often believe that, if we state that each symbol has a real-world counterpart, then any logical mathematical deduction thereafter has such an interpretation also.

This *is* what Science would expect to be the case whenever the assumptions which underlie any proposed 'theorem/theory' were indeed already a well-established scientific model (such as Newton's Law of Gravitation): but, this activity actually becomes a part of the Confirmation (penultimate) Stage IV within the Scientific Method. It is not, however, the totality of the Scientific Method itself: No new science results whenever this specific activity has been successfully done; rather, it would just serve to confirm further an earlier established scientific contribution.

Table I

The Intimate Relationship Shared by Scientific Method and Biological Survival

(A Critical Bibliography)

[Excerpted from "Credibility: Every Computer Programme is a Simulation Model", by
G. Arthur Mihram (P.O. Box No. 1188; Princeton NJ 08542) and
Danielle Mihram (New York University; New York, NY 10012).]

1. *The credibility of computer-directed simulation models is a six-stage model-building process:*
   JOURNAL OF STATISTICAL COMPUTATION AND SIMULATION: 1: 35-44, 1971;
   SIMULATION: STATISTICAL FOUNDATIONS AND METHODOLOGY, 1972 (1970); and,
   OPERATIONAL RESEARCH QUARTERLY 23: 17-29, 1972 (1971).

2. *The Scientific Method is this same modeling process of six stages, conducted historically*:
   IEEE TRANSACTIONS, SMC-2: 621-629, 1972 (1971);
   THEORY AND DECISION 7: 67-94, 1976 (1973); and,
   SCIENCE 191: 790, 1976.

3. *The metaphorical process of Men of letters, of Humanists, is this model-building process, conducted historically over centuries*:
   PROCEEDINGS, SEVENTH INTERNATIONAL CONFERENCE ON CYBERNETICS: 635-644[1], 1973.

4. *The acquisition and accumulation of Human Knowledge is this same modelling process:*
   INTERNATIONAL JOURNAL OF GENERAL SYSTEMS 1: 41-60 AND 281[1], 1974 (1971); and
   MODELING AND SIMULATION 8: 1003-1012, 1977 (1975).

5. *This single model-building process has guided Mankind, in our quest for truth(s), from myth to metaphor to model*:
   PACIFIC TELECOMMUNICATIONS CONFERENCE B6: 30-36[1,2], 1981 (1974);
   GENERAL SYSTEMS RESEARCH AND DESIGN: 537-546[1,3], 1981 (1978); and,
   RELATION BETWEEN MAJOR WORLD PROBLEMS AND SYSTEMS LEARNING: 283-290[3], 1983 (1982).

6. *The neural operation of the adult mind (the learning process) is this same modelling process:*
   ROLE AND EFFECTIVENESS OF THEORIES OF DECISION IN PRACTICE 320-327, 1975 (1972); and
   COMPSTAT 1976: 256-263, 1976.

7. *Each of Popper's Three Worlds (genetic; neural; man-made) is conducted via this same model-building process*:
   SYSTEMS THINKING AND THE QUALITY OF LIFE, 464-473, 1975;
   NATURE 263: 620, 1976;
   AN EPISTLE TO DR. BENJAMIN FRANKLIN, 1975 (1974); and,
   AMERICAN SCIENTIST 67: 394, 1979.

8. *Man's search for necessarily universally accepted truth is Modern Science, conducted by a six-stage modelling process which mimes Nature's survival process*:
   PROCEEDINGS, STATISTICAL COMPUTING SECTION, AMER. STATISTIST. ASS'N: 265-270, 1979;
   CONTRIBUTED PAPERS, 143RD NAT'L MEETING, AMER. ASS'N ADV. SCI.: 26, 1977; and,
   BIOMETRICS 37: 615, 1981.

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1. Paper co-authored.
2. Paper, using the historical perspective to understand this evolution of our knowledge of electricity and magnetism, reveals why our move into our Age of Tele-communications is to date an historical regression, not progression, from the Age of Reason founded on and controlled by the written and printed word.
3. Paper, using comparative religion to note its own historical evolution, the progression of religions worldwide, includes as a logical corollary the resolution of the contemporarily revived debate between evolutionists and creationists.

Of course, if a disparity were to arise here, then scientists would need return to Stage I (Observation + Reflexion), just what did happen to Newtonian theory in the 19th Century—until Adams and Leverrier located Neptune and thereby accounted for Uranus's "misbehaviour" (i.e., for its then observed 'failure' to abide by Newton's Laws).

We conclude this Section by noting that the construction of any scientific model, even though expressed in our language of mathematics, is not conducted by means of the mathematician's theorem-proving process. At a mathematical conference held in Atlanta in the Year 2000, the first two questions to the opening plenary speaker there [10] dealt with this very issue: viz., whether there is any real-world meaning (to much of the work which we do in analyzing time-dependent differential equations) was not at all decisively answered by that speaker, an indecision held, unfortunately, by too many applied mathematicians.

Portion I.D: When are Algorithms (or: When is Mathematics) Better?

We return now to the pertinence of understanding the grammatical distinction between the language of mathematics and computer-programming languages. As Bellman [1,.2] and, particularly, Kemeny [3] were beginning to sense in the 60's, the algorithmic structure of computer programming has advantages greater than does mathematics when we try to capture with scientific credibility the *dynamics* of systems which have biological components.

Today, some of the distinctions which neurologists and embryologists are making in their understanding of what causes an embryonic stem cell subsequently to provide muscular cells rather than neurons is one surely to be ideally described by means of algorithms, yet very likely not so by differential/difference equations.

Indeed, Miller's compendium [9] notes that the *dynamics* of any living system, whether as small as the cell or as complex as a society of organisms, depends upon that system's *decider*. Since the algorithm provides a precise description of a decision-maker, then we should readily concede that computer programming may well be more adept than our language of mathematics in capturing with scientific credibility the dynamics of any system possessing at least one living element.

Miller categorises any living systems as being at one of seven "levels": cells, organs, organisms, and, then, various sets of organisms: groups, organisations, societies, supranational systems. Furthermore, within any level, there exist 19 critical subsystems, the central one of which is the system's "decider": the executive which receives information inputs from all other subsystems and transmits (*communicates*) to them information outputs that *control* the entire dynamic activity of the other 18 subsystems.

Hence, if we are to provide models for the dynamics of any system which contains one or more living elements, then we would be well advised, once we have made and collected our observations on the system, to employ a computer-programming language (rather than mathematics) for the purpose.

Once a system/phenomenon has been observed, mathematics (in particular, differential/difference equations) will remain better suited than computer programming whenever that system/phenomenon is strictly physical (yet, non-biological).

Of course, in order to solve a complicated set of time-dependent differential/difference equations, the applied mathematician may choose to take his resulting mathematical model to a computer and ask that special computer programmes (such as CSMP or DYNAMO) in order to numerically "solve" the equations by means of a steady, regular advance of the variable, time. (Unfortunately, both Jay Forester and the Club of Rome in the

1970s attempted to use these computer programming ‘applications’ to solve the differential equations which they were using to model a particular bio/social system: viz., the political world).

However, biological systems almost never change with such regularity, so that a scientist would be better served to write algorithms (GASP, SIMSCRIPT, e.g.) in order to describe their behaviour, allowing a computer-maintained clocking mechanism to monitor a list of imminent deciders’ respective decision-points, then activating the (already written) algorithm for the next most imminent decider, then advancing the clockworks accordingly so as to mime the dynamics of the real-world (social; biological) system.

Portion I.E: Conclusions to this Point

We need to appreciate that our ‘mathematical sciences’ now contain two (quite distinctly different) linguistic formats, each ideally suited for capturing the dynamics of systems:

strictly physical systems:	via our language of mathematics;
yet, any system with any biological component:	via computer-programming languages.

We have reviewed the literature of our mathematical sciences, including computer science, to reveal two methods by which one can capture concretely the dynamics of any physical system: Mathematics [via difference or difference equation(s)] provides a grammatically third-person approach which, even though—when expressed often as input for a computerised, numerically analytic programme for ‘solving’ numerically the [set of] differential equation[s]—does not take full advantage of the capabilities of computer programming’s <u>algorithmic</u> nature.

Being ‘command languages’, computer programming languages are algorithmic and therefore provide just the very characteristic which one requires in capturing precisely the dynamics of any *living* system, whether at the level of the cell or that of a society or set (of organisms).

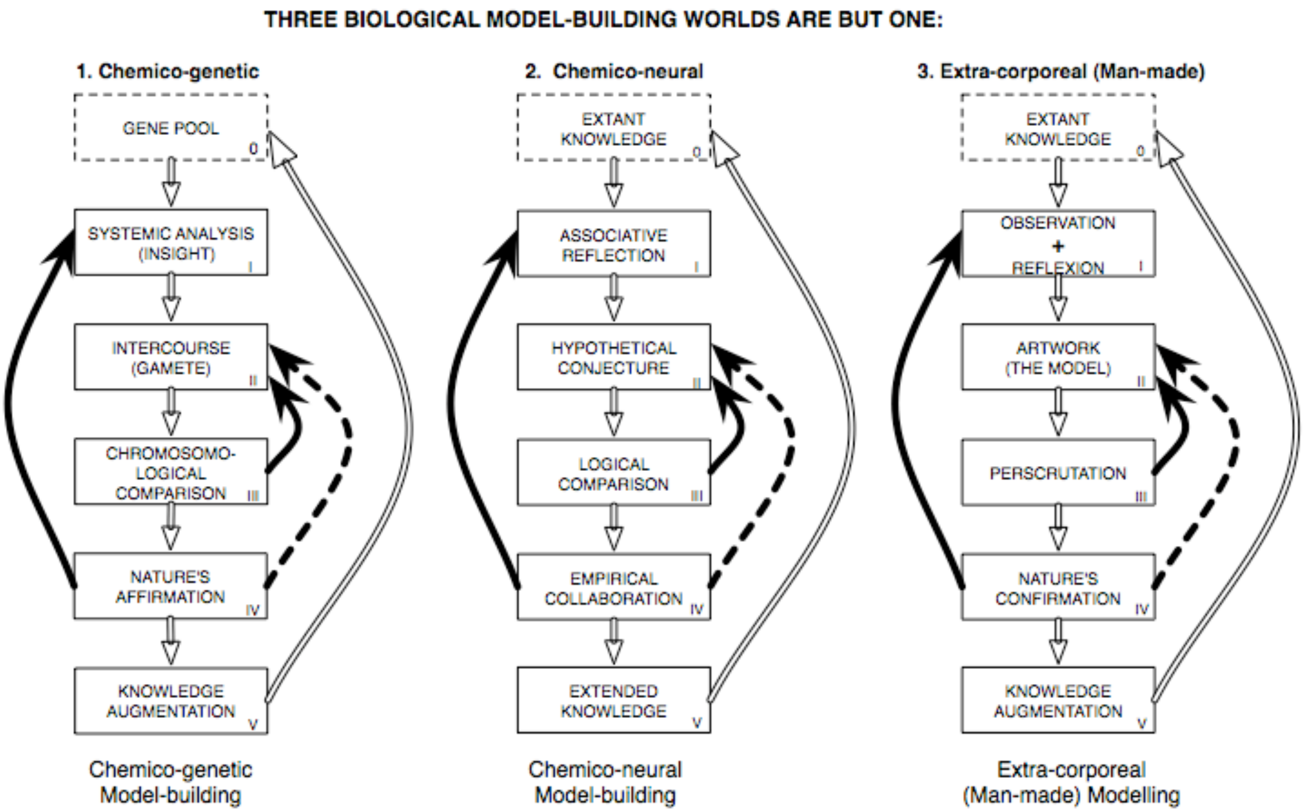
James G. Miller’s compendium, *LIVING SYSTEMS* [9], reveals why algorithms are so applicable to living systems quite generally {cf. also *AN EPISTLE TO DR. BENJAMIN FRANKLIN* [8]: 1975(1974)}.

We have provided examples illustrating this distinction’s pertinence (second-person algorithm vs. third-person equation) in capturing with scientific credibility the dynamics of living (i.e., biological)—as opposed to strictly physical—systems. Our ‘mathematical sciences’, as a result, possess two quite distinct formats by which scientists can model reality.

In addition, we have noted, somewhat in passing, that many mathematicians, applying differential equations in an attempt to provide scientific models, may not be aware that their approach—if adopted as just another exposition of the theorem-proving process of the mathematician—fails to correspond to (i.e. to be) the Scientific Method: Mathematics, a language, is one artform which <u>may</u> be used by a scientist; however, the theorem-proving process of mathematicians is <u>not</u> itself a model of the Scientific Method.

Portion II.Ø: Implications for Tele-communications Policy

The fact—that models of the algorithmic format are not so readily read and interpreted by anyone skeptical of the model’s scientific credibility (cf. Figure 1: Stage III, then IV)—means even more that we require an archival repository for these models, preferably *a machine-accessible archive*. Yet, this machine-accessible archive will serve to ensure that any model, once programmed/published, stored therein will have its integrity maintained, just as is the case for the copyright granted to earlier printed works [See Ref. 13.].



We note also a second widespread concern contemporarily: viz., as noted in the extended abstract affront Portion I of this paper, our newspaper industry is suffering as a result of its inability to 'compete' with Internet-based "coverage" of newsworthy events worldwide [See Ref. 14, e.g.].

We present in this Portion (II) an outline of our earlier work on tele-communications policy. Our fundamental conclusion is that we collectively require a National Electronic Postal Service [NEPS], one operated by the US Government and one providing a certifiable (and a bit enhanced) electronic postmark.

Our NEPS, with its government-issued and –secured enhanced electronic postmark, will provide us with confidence, with the public trust, which we must establish in order to ensure the copyright-protection that our scientific models require [See (15) for a related contemporary antic revealing criminal non-academic behaviour.]. As a corollary, the resulting procedure for establishing an economically-viable "electronic newspaper" can be also ensured.

Portion II.A: Introduction to the NEPS

The recently appointed Director [VAdm (Ret) John Michael Mc Connell] of National Intelligence had sought verbally—at the Armed Forces Communications & Electronics Association's [AFCEA's] Western Conference in Year 2000—a Constitutional basis for attaining superiority in tele-communications: for information dominance and assurance. This call was as if a 'partial echo' of our own 1999 paper [16].

In the present paper, we condense and bring up-to-date that 17-page paper, noting that references to others of our intervening (1999-2008) papers on tele-communications policy are available. We translate Director McConnell's 'echo' into the likely need for the invention and implementation of new technologies so as to expedite security in tele-communications.

Senators Christopher S. Bond and John D. Rockefeller IV, recently Co-chairmen of the Senate's Select Committee on Intelligence, will likely now seek to mandate a 'universal [Internet] service', which has to date been limited to libraries nationally, yet under the restriction that any participating library must provide software for the screening of pornographic materials. This universal (Internet) service should be described, in effect, by the NEPS (outlined below).

In a rather direct response thereto, we provide a procedure by which Congress not only can ensure that it meets its Constitutionally-mandated duty re person-to-person (tele-) communications, but also can provide a new technological "(2^{nd}-generation) V-chip" with a concomitant new technological procedure for ensuring that concerns about both privacy and governmental censorship can be alleviated.

Portion II.B: The Twelve Issues.

We recall the several issues arising in the aforementioned references re person-to-person tele-communications:

1. *An [electronic] postmark*: an assured (preferably, machine-specific!) location and time [GMT: year, day, hour, min sec] of the despatch of any received message/material;

2. *Authentication*: a certified identification of the source of any received tele-communicative message/material;

3. Can there be the electronic equivalent of a *'sealed letter'*?

4. *Classification/Content-markers*: e.g., text, graphic, verbal/musical, video; but also
   A. *Copyright designation* and/or registration of any of the contents;
   B. *Pornography, Violence, Language, Drug-use depiction*: [P,V,L,D]-indicators of contents;
   C. Any *security-based indicators*: whether commercial, governmental, military, or adjudicational.

5. The *[electronic] certificate of mailing*: Could private carriers be deemed reliable in providing this service? The need for a governmentally-operated NEPS with its governmentally-issued (and -secured) enhanced electronic postmark becomes, upon reflexion, rather evident. (Alternatively, could one of the multiple carriers, if under financial stress, be expected to fulfill its obligations here?)

6. The *[electronic] receipt of transmission*: Particularly, a legally-binding certification.

7. Can we provide a reliable "*electronic return address*" as required (or, if desired)?:
   Can 'Caller ID' information be provided? be restricted? even for computer-to-computer transmissions?

8. Within the context of requiring that each transmitter (cf. Item 4, above) provide "electronic content-markers":

How can one avoid concerns regarding (governmental) *censorship*?

9. The *[electronic] signature*": Can this be reliably provided (in the context of being legally-binding)?

10. Whither the *[electronic] carbon copy*, particularly a certifiable one?

In addition to implementing these ten elements regarding individual electronic transmissions, there is a need for *[electronic] authorization* (Item 11: below), particularly for computer-to-computer transmissions. How can one establish, at the message-receiving computer—even though each of the ten elements above were available, and credibly so—that the despatching computer's message, as a request to access and/or to enter a computer-protected file at the receiving end, should be honoured?

The issue of *privacy* (Item 12: below) becomes then paramount. Yet, provision must be made, within the electronic network, for both evidence-gathering and law-enforcement activities of proper governmental officials. Protection of privacy, taken to the extreme, would interfere with the Constitutionally-mandated requirement to provide for 'domestic tranquility'; it then restrains law-enforcement, and, indeed, would hinder the Constitutionally-mandated requirement that Congress "establish justice".

Portion II.C: Their Common Resolution.

We shall address, in turn, these twelve [requisite] issues: paramount to us citizens concerned about the security not only of our government's tele-communications but also of our own personal ones.

A quick examination of the 12 delineated items reveals that we seek to have certifiable and assured confidence (i.e., *trust*) in each of these aspects of person-to-person tele-communications. We shall propose that there is a single solution, one surely acceptable to former Director O'Connell and to Senators Bond and Rockefeller:

Our nation requires a governmentally-operated and a governmentally-secured '*National Electronic Postal Service*' [NEPS].

We do not suggest that the NEPS be exclusionary. Private tele-communicative carriers can surely exist [as per the Pony Express, then the (earlier, though nearly monopolistic) AT&T (Bell System)], though it remains unclear how any one among the multiple carriers could provide the trust expected with respect to any of the twelve features/aspects:

Consider the consequences, whenever any one among them may be failing financially, of that carrier opting to intercept (for politically interested—or sufficiently wealthy—third parties) rather than deliver (as a 'sealed electronic despatch') a particular transmission!

Indeed, as was pointed out earlier {Refs. 8, 16], the requirement for establishing our NEPS derives from two primary historical sources:

α. *THE THREE MUSKETEERS*:

Dumas's historical novel in the 19th Century, related a tale concerning early 17th-century France (and England). The tale is actually one showing the frustration of sending and/or receiving with confidence either messages or parcels despatched over "unsecured roadways" among a choice of "multiple carriers". One of the book's central characters is Cardinal Richelieu, yet he is historically credited with actually establishing the "[national] postal service" ca. 1630, during his life.

β. *THE CONSTITUTION OF THE UNITED STATES OF AMERICA* (1787):

The founders of the American republic noted that there are (only) six reasons for having government, listing these in the document's *Preamble*. The one of primary interest to us in this paper's context is: "to ensure domestic tranquility".

The *Constitution* delineates l7 or l8 duties of its (legislative) Congress, one of which—as a feature designed to ensure domestic tranquility (à la Dumas's later recollection)—is its Clause 7:

> "to establish post-offices and post-roads".

We therefore see, as a Constitutionally-mandated requirement for Congress, that it establish [electronic] post-offices and [electronic] post-roads; i.e., an NEPS (cf. above).

While dealing with this second historical source for the NEPS, one should add that—as another element in government's ensuring domestic tranquility—the authors of the *Constitution* included (Clause 8):

> "to promote the progress of *science* and the *useful* arts, by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries [italics added]."

One could actually add, as a third confirmatory historical basis for our NEPS, that, in the 19^{th} Century, national "PTT" [Post/Tele-graph/Tele-phone] agencies of governments were established throughout Europe and (beyond the European colonies) elsewhere around the world. Though Congress did not opt for this agency, America was quite fortunate that the nearly monopolistic AT&T seemed like a "benevolent [electrical] dictator" in providing person-to-person tele-phonic communications.

We turn, then, to the twelve requisite concerns for the here-outlined NEPS. First, we propose that there be a governmentally-owned (and –operated and –secured) national electronic postal service (= the [electronic] post-offices and [electronic] post-roads of the *Constitution*).

1. Its fundamental feature would be a governmentally-issued electronic postmark, one applied before transmission but upon the NEPS's receipt of any 'electronic parcel' (E-mail, audio, graphical, video):
source (including IP address and point of entry into the NEPS's network)
and *date/time*,
but also *content-markers* (for 'classification of service',
yet including the despatcher's indications of any inclusion of *copyright-registered* material, and , then,
non-zero levels (1 to 9) of [P,V,L,D]: *pornography, violence, language, drug-use depictions*, plus any security-level indicator (intra-business-oriented; governmental tags; military classification; security seals).

As for the 'security' of this electronic postmark: It could be either 'electronically scrambled' via encryption and/or digitally-watermarked, processes controlled within the NEPS, perhaps with randomly timed alterations within the NEPS.

We note the likely need for this "*enhanced electronic postmark*" to include also "biometric data" regarding the sender, information which might be valuable either to an electronic parcel's recipient or to the receiving computer for identification and/or authorization procedures (for granting access to its computer-protected files).

2. The issue of _authentication_ can best be secured, we believe, via the NEPS and its governmentally-secured enhanced electronic postmark, as described above. Of course, the security of the NEPS's encrypting and electronic watermarking process can be enhanced by its (random) alteration from time to unannounced time (as frequently as required).

3. Whither the _electronically-sealed letter_?: We do not claim that the technology yet exists to provide this feature, clearly a fundamental characteristic of the earlier national postal services: one's despatch, even once entered into the postal service, remains his property, is not to have its seal broken, and becomes the property of the addressee only when delivered. Perhaps the NEPS could augment confidence by a procedure such as the above-suggested random (and/or frequent) alteration of its encryption and watermarking procedures.

4. As for _content-markers_ and/or classifications of electronic dispatches, we note that these are rather natural extensions of the earlier postal services. Markers such as "book-rate", "special delivery", "registered/certified mail", even "pornographic contents" have been long used or required to describe contents and/or services. In our Age of Tele-communications, the transmission of video content (e.g., 'video-on-demand' services) and even television broadcasts/Webcasts over the NEPS should require content-markers for any non-zero entry within the postmark's 'content-quartet':

$$[P(1\rightarrow 9), V(1\rightarrow 9), L(1\rightarrow 9), D(1\rightarrow 9)] =$$

[P = pornography: V = gratuitous violence; L = language; D = drug-use depiction].

5/6. _Electronic Certificate of Mailing and Return Receipt of Transmission_: The classification scheme could be easily adapted to note any restricted delivery (within, say, a commercial, academic, or governmental organisation), but can also serve the interest of Congress in providing for us all the [electronic] copyright-protection (See the paper's ensuing Section.). The NEPS's governmentally-secured enhanced electronic postmark can then be equipped to provide the services of "certificates of mailing" and "return receipts of delivery", and can even incorporate biometric data for the added confidence of users.

7. _The Electronic Return Address_ (the 'Caller ID' issue): Since the digitisation of the telephone service, the ability to retrieve (at a message's receiving end) or to suppress (at its despatching end) the "Caller ID" has been a rather standard feature. With VoIP [Voice over Internet Protocol] becoming an intrinsic telephone-computer combination, the ability to continue to withhold the two 'caller ID's" may well need to be a bit compromised, particularly for person-to-person conversations transmitted between computers.

Indeed, the need for a receiving computer to identify the despatching computer, particularly before authorizing (total or restricted) access to its own computer-protected files, may well imply the need to forego the 'Caller ID'options. Perhaps the VoIP-protocols, operating under the NEPS, can resolve the issue via NEPS's securing any revelation of its records of electronic postmarks as well.

8. On _governmental censorship_: Given that the NEPS's enhanced electronic postmark is to include content-markers, even for every computer-directed transmission of a video-on-demand or a Web-casted "TV program", then the despatcher would be required to indicate any non-zero entries within its [P,V,L,D] quartet. A sender—*who has ensured that the electronic payment by himself/herself to the copyright-holder*, or who has been provided the electronic address for that holder—would either provide his/her own non-zero entries or use those of its producer.

Of course, recipients might disagree with one another's [P,V,L,D]-designation(s). We propose that the temptation to allow governmentally-assigned descriptors—even those by the Library of Congress during the copyright-registry procedure—be alleviated by expecting that commercial (or religious-based) services provide their own [P,V,L,D]-designators.

By subscribing at one's home, school, or other institution (library) to one or more such "Electronic Family Circle Magazines", a computer's owner (parent, school principal, head librarian) can 'control' access to any material deemed objectionable to him/her or to his/her 'electronic reviewer' (e.g., any V >2 or D >0, as per the particular 'electronic reviewing service' to which one has subscribed electronically).

9. Whither the "*electronic signature*"?: The NEPS's procedures for establishing the veracity of an actual signature shall likely avoid pattern-recognition technologies, and likely mime those of the electronic banking and credit-card procedures. That such information will now be in the "[electronic] hands" of a governmental agency will require that the NEPS's files be secured, again via the encryption procedures (shallow) and/or the digital watermarking (more dependable) technologies.

10. Whither the *"electronic" carbon copy*?: The NEPS, with its governmentally-issued (and –secured) enhanced electronic postmark, will very naturally provide, for sender and receiver alike, the equivalent of a 'carbon copy'. Actually, its authority will be considerably advanced over that provided by the earlier carbon copies kept in file cabinets for paper documents.

11. Establishing appropriate *authorization* for computer-protected data files: For computer-to-computer transactions, the enhanced electronic postmark, as described above (Item 1)—one including content-markers and/or biometric identifiers—will be ideally suited for establishing—at the receiving computer's terminal—the information required for granting access to requested information for the requestor.

12. Finally, what about the issue of *privacy*?: We maintain that our NEPS, within its enhanced electronic postmark, will provide each of us citizens with a feeling of confidence re the privacy of our personal (taxation, credit-cards, medical, e.g.) records by means of an "Electronic Log-book," one maintained as a standard operating procedure.

We recommend that every such data-protecting computer be required to maintain its own "Electronic Log-book", one recording each request for—and each request granted for—access to its files. A record of the requesting computer's enhanced electronic postmark would be the central feature of each log-entry'; for requests which are granted, the log-entry would also include the exact data for which access was granted.

Furthermore, we recommend that each such computer be required to maintain a 'tickler file' so as to advise—in accordance with the legislation establishing the NEPS—each personal or organizational account of every requested and/or granted entry into its files, including a specification of the actual data accessed.

Government-owned computers cold be expected to behave accordingly, so that any official seeking to 'snoop' on personal data would be required to include in his/her request any requisite permission granted by the concomitantly established "Electronic Court" (cf. Item 9, above).

Portion II.D: A Note Aside on ***Copyright Registration and Protection***

As noted above, the *US CONSTITUTION* requires that Congress provide a copyright (& patent) procedure by which the progress of science and the useful arts can be promoted. Historically, Congress has done little more than establish a Copyright Office (in the Library of Congress) and a separate US Patent Office, though the Congressionally established courts provide the mechanism under which copyright/patent infringements can be adjudicated.

Nonetheless, our move into our Age of Tele-communications has created technologies permitting facile infringement of copyright. Just prior to activity in the 1970s for Congress to re-write, in response, the Copyright Act, xerographic copiers were also permitting facile infringement of the copyright of printed works, though that new Act did not, e.g., require that, thereafter, printers of copyright-registered works must employ inks which would be detectable and that all copying machines be required to protect copyright owners by refusing to make a copy of any (part of) a copyright-registered book or document.

We propose not only that should this correction be included in a new "21st Century Copyright Act" but also that the Act should provide copyright-protection for digitally-recorded materials, even though the Congressional focus in the past few decades has been to please the producers of cinema, video, music, and arts (these mostly would never have been considered Constitutionally "useful") industries. [Would James Madison and Benjamin Franklin, if they could have anticipated our move [8,16] to an Age of Tele-communications, included recordings of performances (musical, theatrical, athletic) as deserving of copyright protection? Printed musical scores and architectural drawings surely qualify, but recorded performances?]

We note that the existence of the NEPS, as described herein, would greatly facilitate the copyright-registration and subsequent copyright-protection of digitized works: The author/producer could transmit, via the NEPS (with its accompanying digitally watermarked and enhanced electronic postmark), his work to the [Electronic] Copyright Office, where it (with its postmark) would be given a "copyright seal"—using digital watermarking—and be returned to the assigned copyright-holder. Any subsequent transmittal of this copy could alert the NEPS to determine from the Copyright Office the conditions under which the document (or its 'fair use') could be transmitted; or, advice any subsequent despatcher of the need to meet the conditions (*monetary or otherwise*) in order to make the copy legally.

The certitude of these NEPS's electronic postmarks would provide the copyright protection which we all should expect, in accordance with our mutual desire to promote the progress of science (and the useful arts).

Indeed, would not such a procedure, one established as 'standard operating procedure' within our NEPS, be the recipe for rescuing the collapsing newspaper industry?

One could acknowledge the recent note by Isaacson [Ref. 17] on micro-charging, by, say, a penny-a-page for online access to the contents of newspapers. Unfortunately, Isaacson found no space there to acknowledge this very proposal [Ref. 16 and its many post-1999 'sequels' on tele-communications policy, including our papers earlier in these TCF Proceedings]:

The digitally-issued electronic copyright-marker would, if implemented as described therein, provide the very procedure for the secure micro-charging for the content of newspapers. He would do well to acquaint himself with these papers' discussions of two aspects of the *CONSTITUTION OF THE UNITED STATES OF AMERICA*: viz., 'post-offices and post-roads' and ' securing… the exclusive right [copyright]' and how they should be addressed in our Age of Tele-communications [See also Ref 8.].

Perhaps Isaacson is revealing his further lack of awareness of the historical underpinnings of the *CONSTITUTION OF THE UNITED STATES OF AMERICA*; after all, in his television-broadcast 'review' of his *BENJAMIN FRANKLIN: AN AMERICAN*, published in 2003, he asserted, quite wrongly, that establishing the American republic was just another 'experiment' for Franklin, rather than being one of the few among Mankind's publications which would qualify as being truly 'scientific politics'!

Portion II.E: Summary

We have summarized for VAdm McConnell, former Director of our National Intelligence—and for Senators Bond and Rockefeller of the Senate's Select Committee on Intelligence—how the technological advances currently extant in our Age of Tele-communications [Tele-computers] can be exploited in order to provide a Constitutionally-mandated National Electronic Postal Service.

These fundamental advances can be thereby implemented so as:

to provide trust in both authentication and authorization procedures;
to restrict the reception of unwanted or illegal (e.g., pornographic) materials;
to avoid concerns about the privacy of one's personal (or commercial) records;
to avoid any concerns of governmental censorship;
and even to provide a concrete proposal for establishing procedures for electronic copyright-registration and the accompanying copyright-protection;
not to mention the likely rescue plan for the newspaper industry.

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